TECHNICAL REPORT NO. 72-4

OPERATION OF THE TONTO FOREST SEISMOLOGICAL OBSERVATORY

Quarterly Report No. 3, Project VT/2704

Contract F33657-72-C-0013
1 January through 31 March 1972

Sponsored by

Advanced Research Projects Agency
Nuclear Monitoring Research Office
ARPA Order No. 1714

Availability

Qualified users may request copies of this document from:

Defense Documentation Center
Cameron Station
Alexandria, Virginia 22314

Approved for Public Release
Distribution Unlimited.

TELEDYNE GEOTECH
3401 Shiloh Road
Garland, Texas

15 April 1972

UNCLASSIFIED
Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author)
Teledyne Geotech
3401 Shiloh Road
Garland, Texas 75041

2a. REPORT SECURITY CLASSIFICATION
Unclassified

2b. GROUP

3. REPORT TITLE
Operation of Tonto Forest Seismological Observatory
Quarterly Report No. 3, Project VT/2704, 1 January through 31 March 1972

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)
Geotech Staff

6. REPORT DATE
15 April 1972

7a. TOTAL NO. OF PAGES
22

7b. NO. OF REFS

8a. CONTRACT OR GRANT NO.
F33657-72-C-0013

b. PROJECT NO.
VELA T/2704

c. APRA Order No. 1714

d. ARPA Program Code No. 1F10

9a. ORIGINATOR'S REPORT NUMBER(S)
TR 72-4

9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. DISTRIBUTION STATEMENT
Approved for Public Release; Distribution Unlimited.

11. SUPPLEMENTARY NOTES

12. SPONSORING MILITARY ACTIVITY
Advanced Research Projects Agency
Nuclear Monitoring Research Office
Arlington, Virginia 22209

13. ABSTRACT

This is a report of the work accomplished on Project VT/2704 from 1 January through 31 March 1972. It describes the operation, evaluation, and improvement of the Tonto Forest Seismological Observatory (TFSO) located near Payson, Arizona, research and test functions carried out at the TFSO, and research and development tasks performed by the Garland, Texas, staff using TFSO data.

DD FORM 1 NOV 65 1473

UNCLASSIFIED
Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Long-Period Array						
Short-Period Array						
Seismograph Operating Parameters						
Multichannel Filter						

IDENTIFICATION

AFTAC Project No:	VELA T/2704
Project Title:	Tonto Forest Seismological Observatory
ARPA Order No:	1714
ARPA Program Code No:	1F10
Name of Contractor:	Teledyne Industries, Inc., Geotech Division Garland, Texas
Contract No:	F33657-72-C-0013
Effective Date of Contract:	1 July 1971
Amount of Contract:	$150,000
Contract Expiration Date:	30 June 1972
Program Manager:	B. B. Leichliter 271-2561, ext. 222

CONTENTS

ILLUSTRATIONS

****

TABLES

ABSTRACT

This is a report of the work accomplished on Project VT/2704 from 1 January through 31 March 1972. It describes the operation, evaluation, and improvement of the Tonto Forest Seismological Observatory (TFSO) located near Payson, Arizona, research and test functions carried out at the TFSO, and research and development tasks performed by the Garland, Texas, staff using TFSO data.

OPERATION OF THE
TONTO FOREST SEISMOLOGICAL OBSERVATORY
Quarterly Report No. 3, Project VT/2704

Contract F33657-72-C-0013
1 January through 31 March 1972

1. INTRODUCTION

1.1 AUTHORITY

The work described in this report was supported by the Advanced Research Projects Agency, Nuclear Monitoring Research Office, and was monitored by the Air Force Technical Applications Center (AFTAC) under Contract F33657-72-C-0013. The effective date of the contract is 1 July 1971; the Statement of Work for Project VT/2704 is included in the appendix of this report

1.2 HISTORY

The Tonto Forest Seismological Observatory (TFSO) was constructed by the United States Corps of Engineers in 1963. TFSO was designed to record seismic events and to be used as a laboratory for testing, comparing, and evaluating advanced seismograph equipment and seismometric recording techniques. The instrumentation was assembled, installed, and operated until 30 April 1965 by the Earth Sciences Division of Teledyne Industries under Contract AF 33(657)-7747. On 1 May 1965, Geotech assumed the responsibility of operating TFSO. The location of TFSO is shown in figure 1.

2. OPERATION OF TFSO

2.1 GENERAL

Data are recorded continuously at the TFSO for 24 hours each day of the week. The instrumentation that accomplishes this, and other instrumentation that is used for special tests, have been operated and maintained during this report period by a staff of four technical people. Administrative work is handled by one half-time person. All work is being accomplished during a "normal shift" from 8:00 a.m. to 5:00 p.m., and a "late shift" from 9:30 a.m. to 6:00 p.m. The normal work shift is worked each Monday through Friday except holidays and is considered the regular work day by all personnel. The late shift is worked every day including Saturdays, Sundays, and holidays, and is staffed by one man on a rotational basis.

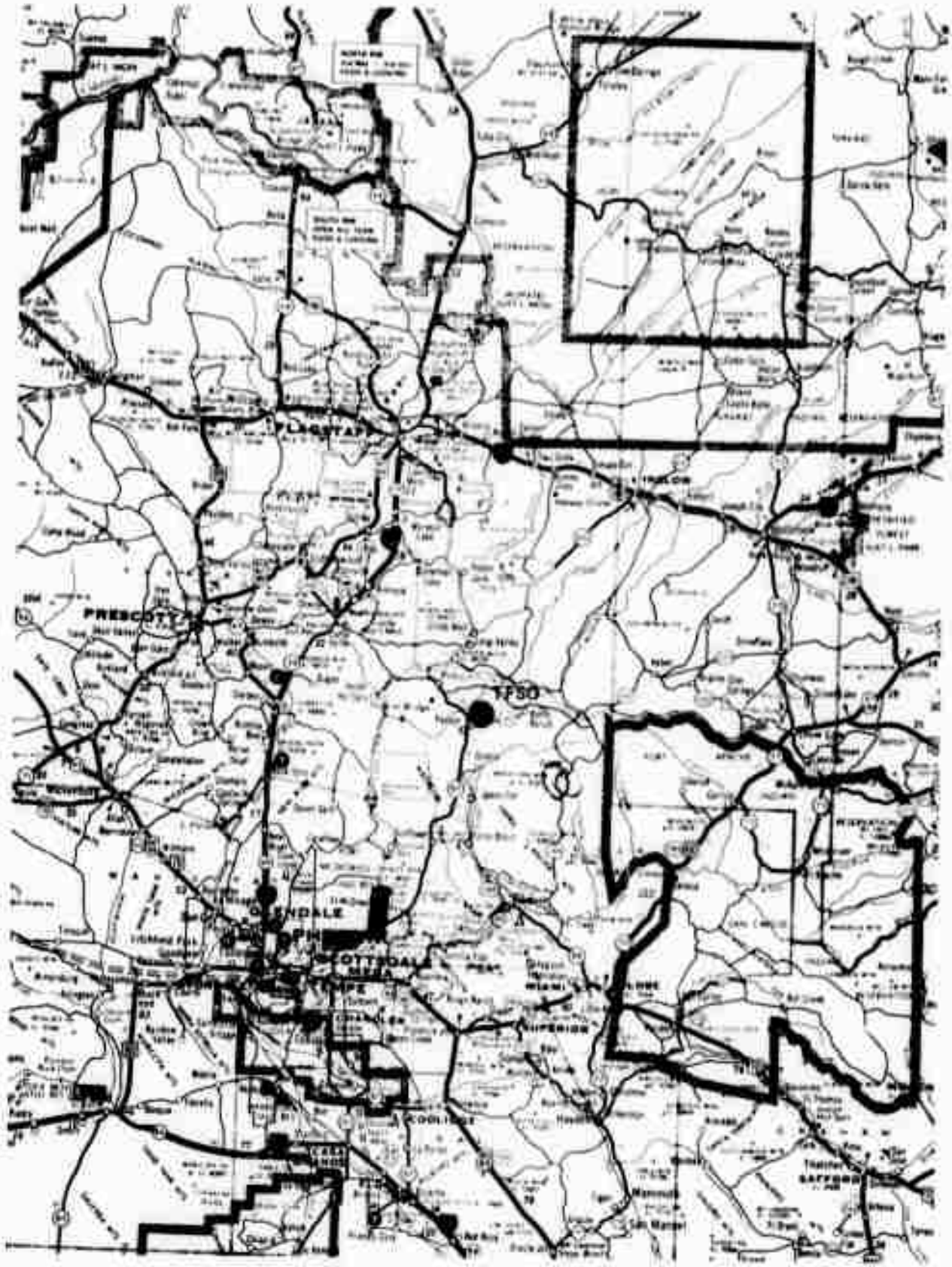

Figure 1. Location of TFSO

2.2 STANDARD SEISMOGRAPH OPERATING PARAMETERS

The operating parameters and tolerances for the TFSO standard seismographs are shown in table 1. Frequency response tests are made routinely and parameters are checked and reset to maintain the specified tolerances.

Normalized response characteristics of TFSO standard seismographs are shown in figure 2.

2.3 DATA CHANNEL ASSIGNMENTS

Each data format recorded at TFSO is assigned a Data Group number. When a data format is changed, a new Data Group number is assigned. Data Format Change Notices reporting changes in channel assignments were submitted to the Project Officer and to frequent users of the TFSO data during this report period.

2.4 COMPLETION AND SHIPMENT OF DATA

Four analog FM magnetic-tape-units were used to record data for the VELA Seismological Center (NYV). Tapes from these units were shipped weekly. All tapes recorded on one day were shipped to our Garland, Texas, laboratory for quality control, then shipped to the SDL. All tapes recorded on the other six days were shipped directly to the SDL.

All ASDAS tapes, except two per week that were sent to Garland for quality control, were held at the observatory for a period of about 8 weeks and then were recycled if not requested by a data user.

All Develocorder (16-mm film) seismograms, except quality control copies, were routinely shipped to the SDL. One seismogram for each Develocorder was sent each week to our Garland, Texas, laboratory for quality control, then forwarded to the SDL.

One DGRDAS tape was sent to Garland each week for quality control, then was forwarded to the SDL. All other tapes were shipped weekly to the SDL.

Copies of calibration and operational logs accompanied all data shipments.

2.5 QUALITY CONTROL

2.5.1 Quality Control of 16-mm Film Seismograms

Quality control checks of randomly-selected 16-mm film seismograms from Data Trunks 2, 4, and 8 and the associated logs were made in Garland. Items that were routinely checked by the quality control analyst include:

a. Film boxes - neatness and completeness of box markings;

b. Develocorder logs - completeness, accuracy, and legibility of logs;

Table 1. Operating parameters and tolerances of standard seismographs at TFSO

Seismograph				Operating parameters and tolerances				Filter settings		
System	Comp	Type	Model	Ts	·s	Tg	·g	Model	Bandpass at 3 dB cutoff (sec)	Cutoff rate at SP side (dB/oct)
SP[a]	Z	Johnson-Matheson	6480	1.25 ·2%	0.64 ·5%	---	---	2B88-1	0.2 - 1.0	6
SP[b]	Z	Johnson-Matheson	6480	1.25 ·2%	0.64 ·5%	0.33 ·5%	0.65 ·5%	6824-1	0.1 - 100	12
SP[b]	H	Johnson-Matheson	7515	1.25 ·2%	0.64 ·5%	0.33 ·5%	0.65 ·5%	6824-1	0.1 - 100	12
SP	Z	Benioff	1051	1.0 ·2%	1.0 ·5%	0.2 ·5%	1.0 ·5%	6824-1	0.1 - 100	12
SP	H	Benioff	1101	1.0 ·2%	1.0 ·5%	0.2 ·5%	1.0 ·5%	6824-1	0.1 - 100	12
SP	Z	UA Benioff	1051	1.0 ·2%	1.0 ·5%	0.75 ·5%	1.0 ·5%	---	---	---
BB	Z	Press-Ewing	SV-282	12.5 ·5%	0.45 ·5%	0.64 ·5%	9.0 ·5%	6824-7	0.05- 100	12
LP	Z	Geotech	7505A	20.0 ·5%	0.77	---	---	30024	80 - 300	6
LP	H	Geotech	8700C	20.0 ·5%	0.77	---	---	30024	80 - 300	6

KEY

SP Short period
IB Intermediate band
LP Long period
UA Unamplified (i.e., earth powered)
BB Broad band

Ts Seismometer free period (sec)
Tg Galvanometer free period (sec)
·s Seismometer damping constant
·g Galvanometer damping constant

[a]37-element hexagonal array

[b]Linear array and 3 comp

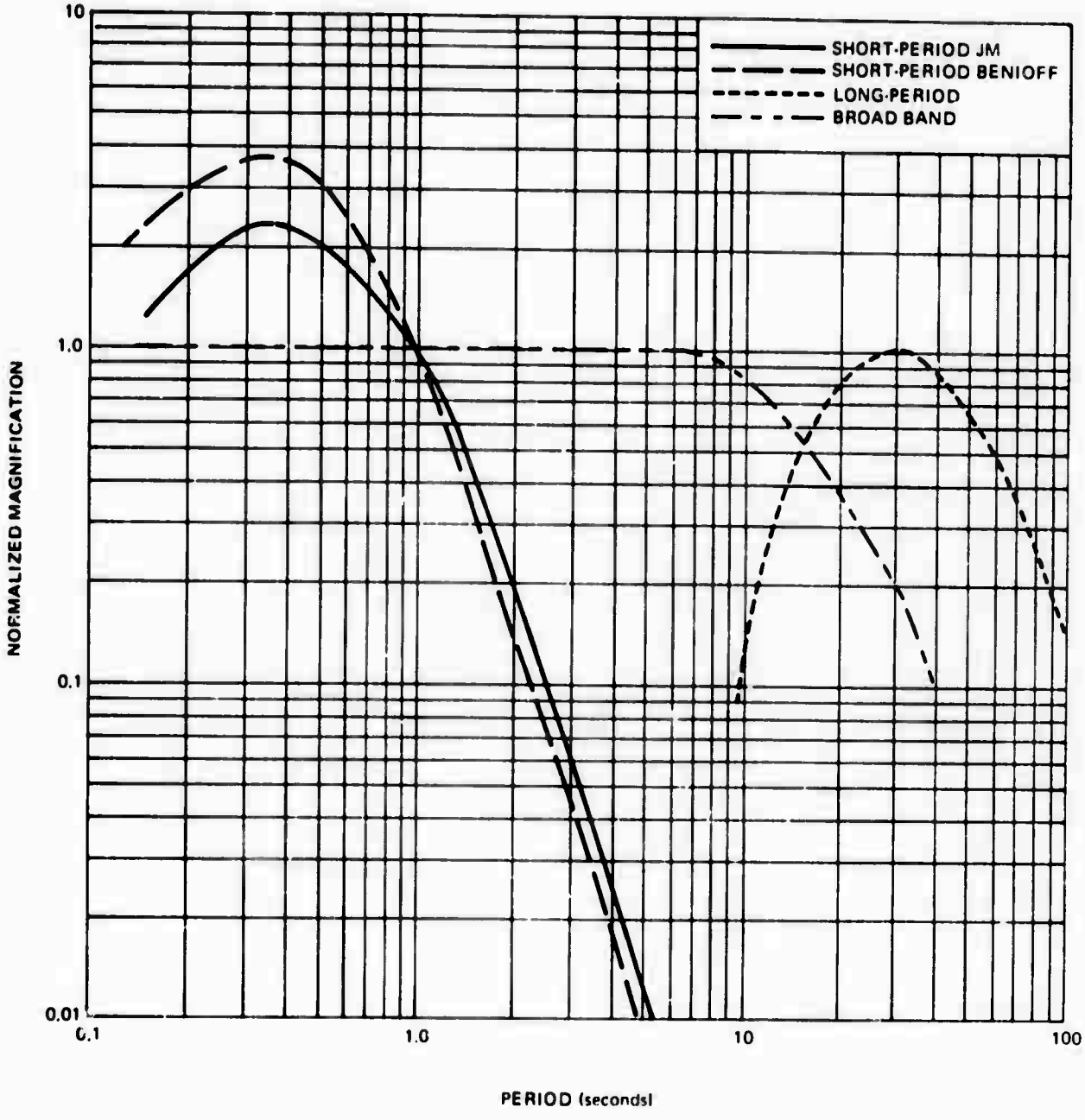

Figure 2. Normalized response characteristics of standard seismographs at TFSO

G 5048

c. Film -

(1) Quality of the overall appearance of the record (for example, trace spacing and trace intensity);

(2) Quality of film processing.

d. Results of these evaluations were sent to the observatory for their review and comment.

2.5.2 Quality Control of Analog FM Magnetic-Tape Seismograms

Each week, quality control checks of three randomly-selected magnetic-tape seismograms are made in Garland and at TFSO to assure the recordings meet specified standards. The following items are checked:

a. Tape and box labeling;

b. Accuracy, completeness, and neatness of logs;

c. Adequate documentation of logs by voice comments on tape where applicable;

d. Seismograph polarity;

e. Level of the microseismic background noise;

f. Level of calibration signals;

g. Relative phase shift between array seismographs;

h. Level of system noise;

i. Oscillator alignment;

j. Quality of recorded WWV signal where applicable;

k. Time-pulse carrier;

l. Binary-coded digital time marks.

2.5.3 Quality Control of ASDAS Magnetic-Tape Seismograms

Quality control checks of ASDAS tapes are made routinely. At present, one tape from each of the two transports is checked weekly for the following items:

a. Neatness and accuracy of the associated logs;

b. Polarity errors;

c. Recording level of each channel;

d. Fidelity of reproduction;

e. Presence of header record and correct record length;

f. Tape parity errors;

g. Timing information.

2.5.4 Quality Control of DGRDAS Magnetic-Tape Seismograms

Quality control checks of DGRDAS tapes are made routinely. At present, one tape is checked each week for all items listed under section 2.5.3 and, in addition, for the following items:

a. Field transmission parity errors;

b. Central digital system parity errors;

c. Gain code errors.

2.6 INSPECTIONS

A security inspection was conducted on 2 February by Mr. M. Craig, Chief, Industrial Security, Phoenix, Arizona. All phases of the TFSO security program were found to be in good order.

2.7 EMERGENCY POWER GENERATOR

The 100 kW diesel-powered generator was operated for a total of 4.2 hours. It was operated 0.3 hour during commercial power failure and 3.9 hours during full-load tests.

2.8 FACILITY MAINTENANCE

The TFSO facilities were maintained in accordance with sound industrial practices throughout the report period. This work included pest extermination, fire extinguisher inspection, work area cleaning, and lubrication and cleaning of the heating and air conditioning equipment.

2.9 WEATHER

There was no lightning nor any precipitation in the TFSO area during this quarter, and the temperature at the Central Recording Building varied from a minimum of 9°F to a maximum of 84°F.

2.10 RELOCATION OF LP6

The work of planning and preparing for the relocation of LP6 continued during this report period. On 19 January, the access road to the proposed new site was surveyed. On 7 February, Captain John H. Fergus, Project Officer, Mr. Charles Thurber, USAF, Mr. B. B. Leichliter, Program Manager, and Mr. Gayle Stanfill, TFSO Station Manager, met with Ranger Ken Bishop at the proposed LP6 site to coordinate permitting of that site. Later, the same individuals met in Phoenix with Mr. Wirth, the Tonto Forest National Forest Supervisor, to continue this coordination. Mr. Wirth agreed that the new site need not be fenced as all of the installation would be underground, but concurred with other Forest Service requirements which called for the repair of the existing Forest Service road, the closure of the remaining 1.6 miles of road, and the construction of the 0.14 mile of access road according to the Forest Service Engineer's requirements.

On 10 February, Captain Fergus and Mr. Leichliter met with Mr. Dave Reichart, Corps of Engineers, in Phoenix to review our request to the Forest Service for the relocation of LP6.

On 25 February, our Engineering Change Proposal No. 1, P-1960, for the Relocation of LP6, was negotiated.

On 20 March, Mr. Stanfill met again with Ranger Bishop to discuss road construction at LP6. He approved the plans submitted to him at this time and forwarded copies of these to his division office for their approval.

2.11 SPIRAL-FOUR CABLES

Thirty-five sections and three half-sections of cable were replaced, and three cables were spliced during January, February, and March. One cable had been shot and two had been cut by tractors. Two cables had pieces cut from them and removed by vandals. The remainder failed because of insulation damage.

Ranger Phil Smith met with the Project Officer, the Program Manager, and the Station Manager on 9 February to discuss TFSO cable damage by the Forest Service Engineers and by Southwest Forest Industries. He stated that cable damage would be a continuous problem during their annual rehabilitation work because the cables were near roads and in ditches, but indicated that Southwest Forest Industries probably would not be permitted to cut wood in areas through which our cables pass.

2.12 RADIO SYSTEMS

Applications for renewal of the LP array microwave telemetry station license and the observatory communications system license were submitted during this report period.

2.13 LP5 POWER GENERATOR

Routine maintenance, including changes of oil, oil filter, and air cleaner, and filling of water and oil reserves was performed in January and in March. One hundred gallons of fuel were added to the supply tank in January and 500 gallons were added in March.

3. INSTRUMENT EVALUATION

3.1 LONG-PERIOD TRIAXIAL SYSTEM

Operational testing of the LP/SP triaxial system was resumed during January with the ZTSP, NTSP, and ETSP channel magnifications set to 1200K. During February, filter settings were adjusted to bring the triaxial system frequency response closer to the TFSO short-period system response and the ZTSP, NTSP, and RTSP channel magnifications were reduced to 965K. The triaxial system was deactivated on 13 March and sensor modules were shipped to McClellan AFB on 15 March.

3.2 DIGITAL GAIN RANGING DATA ACQUISITION SYSTEM

The digital gain ranging data acquisition system was operated throughout the report period with interruptions only for record changes and routine maintenance.

3.3 ASTRODATA SEISMIC DATA ACQUISITION SYSTEM

The Astrodata seismic data acquisition system was operated continuously throughout the report period except during the unmanned observatory hours, and during periods of maintenance and record change. Maintenance to the system included routine cleaning; the replacement of a photosense lamps, vacuum motor brushes, and a vacuum motor; the adjustment of supply reel locking hubs; and the repair of supplies which power the active filters.

3.4 MULTICHANNEL FILTER

The MCF was operated throughout January, but its output was generally of poor quality because many of the short-period array channels that feed data to the MCF were either noisy or inoperative. In addition, the MCF power circuit breaker opened several times, indicating that some component part was failing intermittently. During February, the filter was operated with inputs from 16 short-period array channels. The other three channels were noisy and were not used. On 2 March, the Z10 channel became inoperative and remained in that condition throughout the remainder of this reporting period.

3.5 GRAVITY FEED CHEMICAL SUPPLY SYSTEM

During the first 12 days of January, the gravity feed chemical supply systems dispensing fixer to the short-period Develocorders continued to fail frequently while identical systems in the long-period Develocorders operated without interruption. Installation of manifolds that used three valves in parallel to control the flow rates for each short-period Develocorder temporarily stopped failures, but these eventually became clogged and interrupted film fixing.

A significant improvement in the performance of all SP Develocorder gravity-feed systems areas was realized when General Electric Supermix Fix was used in place of Kodak Rapid Fix. Details of all tests performed will be presented in a separate letter report.

3.6 EXTENDED LONG-PERIOD SEISMOGRAPH

The extended long-period seismograph, ZXLP, was operated at a magnification of 140K throughout the report period.

3.7 SHORT-PERIOD 37-ELEMENT ARRAY SEISMOGRAPH

Data from short-period array channels Z1 through Z20 were recorded routinely during this report period. Most of these channels were noisy or completely inoperative during a substantial portion of January because of cable leakage or cable failure. During February, 14 channels operated continuously with low system noise, 4 channels were intermittently noisy and two channels failed and were repaired. All channels operated satisfactorily from 1 to 29 March, when Z10 became inoperative.

3.8 LONG-PERIOD ARRAY

Data from the long-period array channels were recorded throughout this report period. Channel failures were corrected by the replacement of one amplifier and several cables, the recentering of masses on six instruments, and the cleaning of one cable hook.

3.9 QUARTZ ACCELEROMETER

On 25 February, our Engineering Change Proposal No. 2, P-1976, Evaluation of Quartz Accelerometer, was negotiated. We will begin work on this task upon receipt of equipment to be evaluated.

3.10 LAMONT-DOHERTY SEISMOMETER ENCLOSURE

Because of the delays in beginning the relocation of LP6, one Lamont-Doherty Seismometer Enclosure (Lamont tank) was installed on a good granitic rock outcrop, approximately 25 feet from the existing experimental tank vault, and 1/4 mile northwest of the east walk-in vault. Figure 3 shows a sketch of the Lamont tank installation plan.

The installation was begun on 22 February and was completed on 15 March. It is planned to install identical horizontal LP seismometers in the Lamont and experimental tank vaults, orient them to sense east-west signals, and to record their outputs on adjacent Develocorder channels and on magnetic tape.

4. PROVIDE OBSERVATORY FACILITIES AND ASSISTANCE TO OTHER ORGANIZATIONS

4.1 VISITORS

Lt. Lawrence Michard and two aides from the Army Special Force visited TFO on 25 January to study site and cable locations in preparation for an invasion of the Tonto National Forest by the Army, the Marines, the Airborne Forces, and the Special Forces (Green Berets) which will begin on 1 February. Their two main camps will be in East Verde Park, near Z13. The Special Forces group will teach mountain survival to the other military personnel. The group was given a tour of the observatory, and operations were discussed. We were assured that the troops will not damage our cables or sites.

Mr. D. Minnegale, Honeywell, Phoenix, Arizona, visited TFSO on 6 January to discuss problems associated with the maintenance of our FM tape recorders. He stated that spare parts will no longer be stocked for the recorders, but that they can be manufactured on special order. It is Honeywell's policy to stock spare parts for only seven years after the manufacture of an item is discontinued.

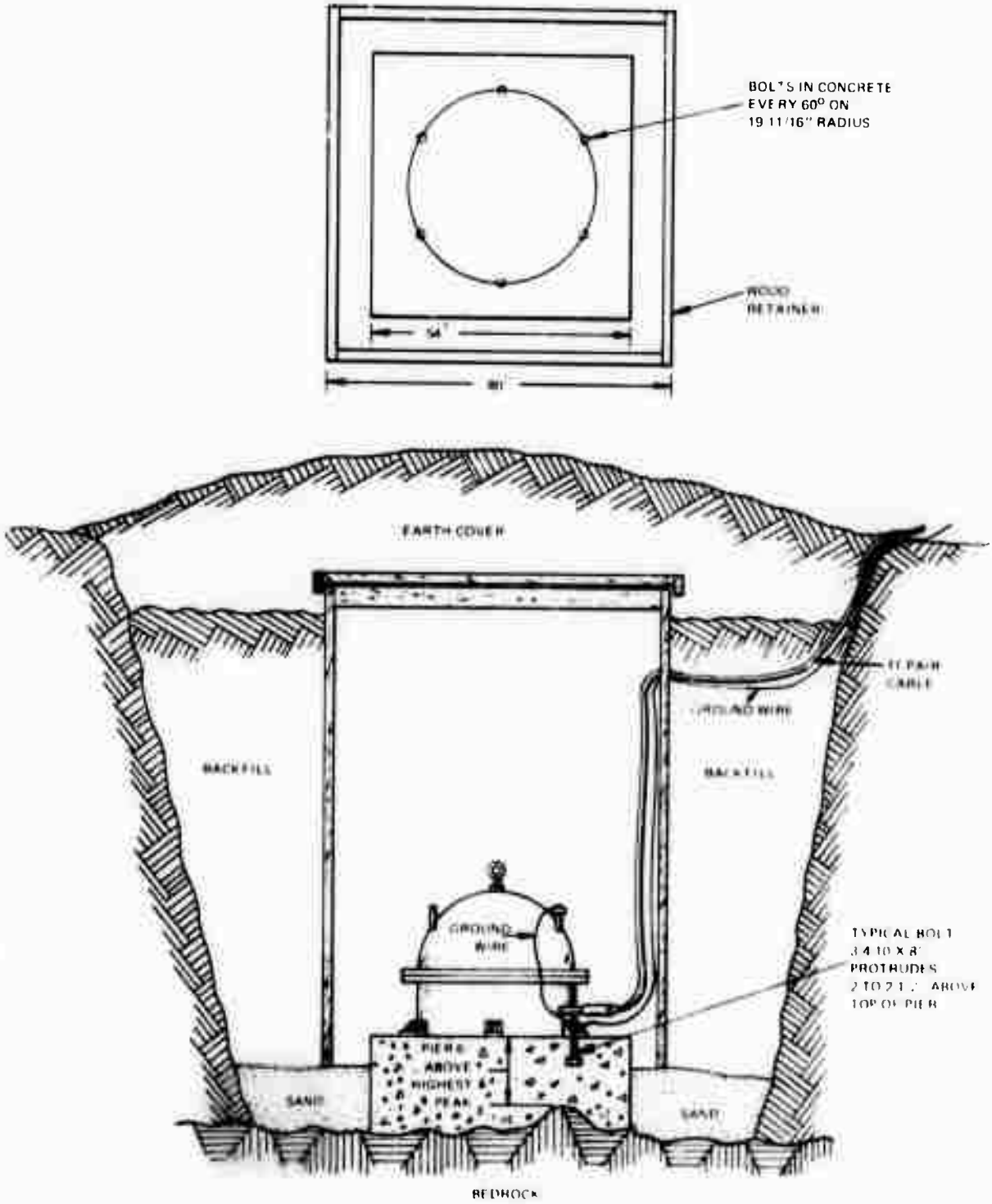

Figure 3. Lamont tank installation

APPENDIX to TECHNICAL REPORT NO. 72-4

STATEMENT OF WORK TO BE DONE

27 JAN 1971

STATEMENT OF WORK TO BE DONE
(AFTAC Project Authorization No. VELA T/2704/B/ASD)

1. Objectives. The Tonto Forest Seismological Observatory (TFSO) is unique in its low level of background seismic noise and in its capability as a research center, being equipped with various film, paper and analog and digital recorders, a shake table, a large walk-in vault for instrument evaluation, and assorted test and measurement equipment. The purpose of this project is to operate this observatory as a source of high-quality seismological data for use in Government-sponsored research projects, to use the TFSO as a field test site for evaluation of new seismological instrumentation and procedures, and to support other research projects as identified by the project officer. This project should require a manning level of approximately five man-years.

2. Tasks.

a. Operation.

(1) Continue operating the TFSO according to established procedures (Standard Operating Procedures for TFSO, 1 Nov 1970), providing recorded data to the Government. Special data requirements anticipated will include, but not be limited to, recording signals from special events at the Nevada Test Site and supplying beam-formed or multichannel filtered data for use in evaluation of the effectiveness of the ARPA long-period arrays: Montana Large Aperture Seismic Array, Alaskan Long-Period Array, and Norwegian Seismic Array.

(2) Quality control the data acquisition systems and evaluate the seismic data recorded to determine optimum operating characteristics and perform research to improve operating parameters to provide the most effective observatory practicable. Major reconfigurations in equipment, those requiring more than 48 hours to remove, are subject to prior approval by the project officer.

(3) Provide use of observatory facilities and seismological data to requesting organizations and individuals as identified by the project officer.

(4) Maintain, repair, protect, and preserve the facilities of TFSO in good physical condition in accordance with sound industrial practice.

b. Instrument Evaluation.

(1) Evaluate the performance characteristics of experimental equipment identified by the project officer. This work involves investigation of such components as seismometers and amplifiers, combinations of components such as are involved in lightning protection

Atch 1

improvement, and altered modes of operation such as radio transmission of data. These necessary investigations will be initiated only after advances in the state-of-the-art identify problems needing work. At present, the following areas for possible investigation are:

(a) Long-term field testing of a new version of the Geotech 23900 long-period seismometer incorporating an internal feedback system.

(b) Test and evaluation of a horizontal short-period array according to existing general operating procedures contained in Standard Operating Procedures for TFSO, 1 Nov 1970.

(c) Evaluation of an intermediate-frequency range system to be provided by the Government for recording of reflected body phases.

(d) Evaluation of special on-line signal detection algorithms.

(2) Maintain the equipment necessary to perform the above mentioned evaluations, including the shake table, signal conditioning and recording equipment, test and calibration instrumentation, and film viewers.

c. Upon identification and prior to the disposition of any equipment determined to be excess to the needs of the project, the contractor shall notify the project officer.

2